

9.0 BASELINE ECOLOGICAL EVALUATION/ECOLOGICAL ASSESSMENT

9.1 Introduction

The following is the completed BEE/EA for the North Field/Main Yard, Central Yard and East Yard areas of the Chevron Refinery in Perth Amboy, New Jersey (Figure 9-1). This evaluation was performed, in part, to comply with the surface water and sediment investigation provisions of Chevron's RCRA Corrective Action Permit (RCRA Corrective Action Permit, Appendix A, Scope of Work for RFI) and requests by NJDEP for a BEE pursuant to TRSR Section 3.11. The BEE is limited to an evaluation of ecological receptors and, as requested by the NJDEP, has been prepared in accordance with the BEE format described in the TRSR.

The purpose of the BEE/EA was to identify the potential co-occurrence of:

- Contaminants of ecological concern at the site;
- Environmentally sensitive natural resources, as defined by TRSR Section 1.8, within the site boundaries and/or on properties immediately adjacent to the site; and
- Potential migration pathways and impacts to on-site or adjacent environmentally sensitive natural resources that may be due to site operations.

The sources of information used to complete the BEE are listed in Section 2.0. Also, a BEE site inspection was conducted by TRC Raviv on June 12, 2003.

9.1.1 Environmental Setting

The Refinery is located in an older industrialized, coastal area of New Jersey. The North Field/Main Yard, Central Yard and East Yard areas of the Refinery are situated on a 368-acre site in Perth Amboy, Middlesex County, New Jersey. Figure 2-1 is a general vicinity map showing the Refinery's location. In general, the site is bound to the north by Woodbridge Creek, to the east by the Arthur Kill, to the south by industrial properties, and to the west by the Pennsylvania Railroad tracks. A description of the four geographical areas of the Refinery is provided below:

North Field

This area consists of ASTs, piping and pumps, the ETP and associated stormwater tanks, and the FFTG. This part of the Refinery is the most heavily associated with waste management including: the Short Term Hazardous Waste Storage Area, the NFB, the Surge Pond, the Leaded Weathering and Fines Transfer Areas, and the Vanadium Pentoxide Reactor Burial Area.

Main Yard

This area is the primary process area at the Refinery, both presently and historically. Areas include ASTs, Crude Unit No. 5, piping and pumps, bulk loading rack, new Power Plant, and NaSH Plant. This area previously contained Crude Units No. 3 and No. 4, the Hydrotreater and VGO, Hexane Plant, Rheniformer, PA Plant, and Lead Plant which have been demolished and sold for scrap.

Central Yard

This area includes ASTs, liquid petroleum gas storage vessels, asphalt railcar loading racks, motor fueling station (1 UST), a shop building, and a dumpster area. The Central Yard also formerly contained process units including the Catalytic Cracker, No. 2 Rheniformer, and Alky Plant.

East Yard

This area consists of ASTs, the Asphalt Plant, asphalt truck loading racks, wharf, EYB, TBA Warehouse (PCB Storage), AAB Plant, Diesel Fuel Station (UST), Truck Scale, and the Administration Building with Annex.

9.1.2 Surrounding Land Use

The following industrial properties border(ed) the Refinery:

- Witco Chemical;
- Bird and Sons Landfill;
- Joline Properties;
- ASARCO;
- Amerada Hess;
- American Cyanamid;
- Jadler Metals;
- Haagen-Dazs;
- Englert, Inc.;
- Russel Stanley Corp.;
- CP Chemical Inc.;
- Shell Oil Company; and
- Empire Polymer Corp.

In addition, small businesses along State Street, including R&L Towing, T&I Transmissions, Sylvan Industrial Piping, and Abe Golub Used Cars, border the Central Yard. Residential properties also border the south side of Amboy Field and the West Yard.

The following subsections contain brief descriptions of these properties, including available information regarding potential environmental issues related to their operation.

Witco Chemical

Witco Chemical (Witco) is located at 100 Convery Boulevard, adjacent to the north boundary of Amboy Field. Witco is a RCRA generator and transportation, storage and disposal (TSD) facility that discharges stormwater and non-contact cooling water to Spa Spring Creek under an NJPDES permit. Witco also discharges process water to the Perth Amboy sewers and the Middlesex County Utilities Authority.

The Witco plant established operations in 1948 and produced polyester resins such as ADAP esters, metallic stearates, and surfactants and intermediates, including specialty surfactants such as amines, glycols, and fatty acids.

Virgin and waste heptane, generated at the rate of approximately 1,000 gallons per week, were formerly stored in a UST (until approximately 1986). Various other tanks and reactor vessels store raw materials for a rubber accelerator plant. Waste organic materials from this process are manifested for off-site treatment and/or disposal. The on-site laboratory generates a waste solvent mixture of methanol, toluene, isopropanol, ethanol and pyridine. Other wastes include off-specification raw materials and products as well as cleanup materials including PCB contaminated soils and lead contaminated soils.

Bird and Sons Landfill

The Bird and Sons Landfill site is located near the intersection of Maurer Road and Amboy Avenue, north of the West Yard and west of the North Field/Main Yard area. The landfill on the property reportedly accepted non-chemical industrial waste. Four groundwater wells were located on the property, which were sampled from 1986 to 1989. VOCs were not detected in the samples. Used USTs and other debris are stored on the property. Used UST cleaning operations may have been conducted on the property.

Joline Properties, Inc.

Joline Properties, formerly Bird, Inc., is located on Amboy Avenue along the Pennsylvania Railroad tracks, east and upgradient of the North Field. The property was the site of an asphalt roofing shingle production facility that began processing asphalt materials in the 1920's.

ASARCO

The ASARCO property is located at 1160 State Street, along the southern boundary of the East Yard. The site is located on the Arthur Kill and during its operational history as a metal smelter and refiner, had an operational pier on the waterway. The ASARCO property was operated as a non-ferrous metal refinery from 1894 to 1976. Releases of various contaminants, including metals have been documented at the ASARCO property.

Amerada Hess

The Amerada Hess Perth Amboy Terminal is located at the confluence of Woodbridge Creek and the Arthur Kill, along the north side of the East Yard. The Hess facility is a bulk terminal with 45 ASTs with a combined storage capacity of 1.1 million gallons. Products stored include No. 2, No. 4 and No. 6 fuel oil, kerosene, diesel fuel, pour depressant and gasoline. Hess previously stored methanol. Stormwater was managed by three on-site oil/water separators that discharge to Woodbridge Creek and the Arthur Kill.

American Cyanamid

The American Cyanamid, Inc. facility (Cyanamid) operated on Cutters Dock Road in Woodbridge Township, north of the North Field on the opposite bank of Spa Spring Creek. Cyanamid owned and operated this facility starting in 1932. An NJDEP inspection report (1983) indicates that Cyanamid manufactured industrial chemicals associated with water treatment, paper manufacturing, drilling mud conditioners, and inorganic catalyst used for production of sulfuric acid.

Cyanamid was issued an NJPDES-DGW permit in June 1986 to monitor the potential impact of a lined surface impoundment and a closed one-acre landfill. Groundwater elevation contour maps indicate that the groundwater flow direction beneath the site was towards Spa Spring Creek and Woodbridge Creek. The surface impoundment was a pH equalization/aeration lagoon that was installed in 1974 to receive process water, stormwater runoff, and septic waters generated onsite. The water was reportedly held in the impoundment 24 hours prior to transfer to Woodbridge Township for treatment.

The landfill is located near Spa Spring Creek. The dates operated, contents, and aerial extent were not documented in the files reviewed for this report. The landfill area is visible on 1961 and 1967 aerial photographs. The 1961 aerial photograph shows the landfill encompassing approximately 0.4 acres with its southern boundary within 25 feet of the northern bank of Spa Spring Creek.

Jadler Metals

Jadler Metals, located at 1060 State Street, reclaimed metals and salvaged used electronic components as a registered hazardous waste generator (USEPA Facility No. NJD980783658). The Jadler facility has been reported to manage mercury relay tubes,

radium-226 bromide tubes, krypton-85 cathode tubes, lead cables, copper wire, and batteries. An NJDEP inspection reported an on-site inventory of 30,000 pounds of mercury tubes, 24 55-gallon drums of less than 50 ppm PCB wastes from electrical components, 1,400 radium bromide tubes, and 16,600 krypton tubes.

Englert, Inc.

Englert, Inc. was located at 1200 Amboy Avenue, west of Chevron's North Field area of the Refinery. The Englert property is separated from the Refinery by the Pennsylvania Railroad tracks. Englert operated a metals processing facility that used heavy metals in solution and generated wastewater from a paint-line manufacturing facility. In addition to heavy metals and solvents, the Englert facility used sodium bisulfates, sulfuric acid, lime and flocculating polymers.

Wastewater was processed by an on-site wastewater treatment plant that generated a heavy-metal sludge, which was sent to S&W Waste in Kearny as a hazardous waste. Waste oil removed by the on-site wastewater treatment facility was burned in an on-site incinerator. The treated wastewater is discharged to the sewer to the Middlesex County Utility Authority.

Russel Stanley Corp.

Russel Stanley was located on Convery Boulevard, northwest of the North Field; it is not directly adjacent to the Refinery. Russel-Stanley was a manufacturer of plastic and steel drums.

CP Chemical Inc.

CP Chemical was located on Arbor Street in the Sewaren section of Woodbridge Township. The CP Chemical facility forms the northern boundary of the Refinery's NFE. CP Chemical performed metals recovery and recovery from various waste materials. Extensive releases and regulatory actions are associated with the CP Chemical facility, including metal (copper, nickel and zinc) releases to soils, groundwater and surface water.

Shell Oil Company

Shell Oil Company is located at 111 State Street in Sewaren. The site borders the Refinery to the North, across Woodbridge Creek and to the north and west of the NFE. The Shell Facility functions as a terminal, distributing gasoline to vendors and storing various petroleum products in ASTs. No processing or refining of petroleum products occurs at the facility. Subsurface contamination has been documented at the site.

Empire Polymer Corporation

Adjacent to the Refinery, at 1031-1057 State Street in Perth Amboy, is the site of the former Empire Polymer Corporation, also known as Express Marketing, Inc. The company

packaged and distributed plastic material. The facility remained operational until April of 1993, when a fire destroyed the building. After the fire, the building was demolished, leaving only an empty lot.

9.1.3 Adjacent Surface Water Bodies

Three surface water bodies border portions of the Refinery along its northern boundary (Spa Spring Creek and Woodbridge Creek) and eastern boundary (Arthur Kill) (see Figure 9-1). In the vicinity of the Refinery, Woodbridge Creek and Spa Spring Creek are tidal estuarine waters. Thus, water flow and elevation in the creeks are controlled by the diurnal tide cycle. Woodbridge Creek is bounded by mudflats and tidally-flowed wetlands, as well as numerous industrial properties. At high tide, the Creek is approximately 100 feet wide as it flows past the Refinery. Woodbridge Creek empties into the Arthur Kill several hundred feet north of the Refinery's East Yard. Spa Spring Creek is a smaller, man made channel that empties into Woodbridge Creek at the NFB area of the Refinery.

The Arthur Kill itself is a tidal strait connecting the Kill van Kull and Newark Bay to the north with Raritan Bay and the Raritan River to the south. Tidal surges come from both ends, with an average flushing time of two weeks and an average semi-diurnal tidal range of 1.6 meters (5.3 feet). The major freshwater inputs are the major tributaries of the Arthur Kill: the Rahway River, the Elizabeth River, and the Fresh Kills, which contribute about 38 percent (122 cubic feet per second (ft³/sec)), with the balance of 62 percent (200 ft³/sec) coming from smaller tributaries, sewage treatment plants, combined sewer overflows, and industrial discharges. The salinity of the Arthur Kill varies from 17 to 27 parts per thousand (ppt) at the southern end to nearly freshwater in some of the tributary mouths. The Arthur Kill is surrounded by one of the most densely populated coastal areas in the world.

Vast modifications of the physical features of the Arthur Kill were made to serve the harbor area. The highly industrialized waterway is dredged to an average channel depth of nine meters (30 feet) and much of the shoreline is comprised of bulkheads or rip-rap. In addition to vegetated wetland areas, the vicinity contains extensive interspersed areas of man-made structures, including railroad yards, oil tank farms, bulkheads, docks, road systems, landfills, and numerous industrial and residential buildings, both occupied and abandoned.

Historically, the Refinery has discharged treated wastewaters to outfalls located in Spa Spring Creek and Woodbridge Creek. The Refinery's current NJPDES permitted wastewater discharge is located in Woodbridge Creek.

9.1.4 Geology and Hydrogeology

Site Geology

The general stratigraphy of the Refinery consists of six major units which overlie the bedrock, including fill, organic clay and peat, glacial till and outwash, and Raritan Formation sand and clay. The surface and shallow soils are composed of fill over large portions of the

site, which is generally less than ten feet thick, but can be up to 20 feet thick. In some areas, the fill appears to be derived from on-site glacial deposits, and consists largely of sand, with variable amounts of silt, clay and gravel. Non-indigenous material in some areas of the fill includes miscellaneous debris, ash, construction debris, and catalyst beads. Fill was placed directly on top of marshland and other existing native soils before the construction of surface impoundments during the 1960's, and fill was used to build up dikes around the edges of the impoundments.

Clay soils beneath the site include the Raritan Fire Clay ranging in thickness from 12 to 20 feet and the Woodbridge Clay, which is less than 50 feet thick. The Farrington Sand is 15 to 25 feet thick and is continuous beneath the site, except at the eastern section adjacent to the Arthur Kill, where it was apparently removed by erosion.

Bedrock was encountered in several deep borings on-site at 65 to 85 feet bgs. There is a layer of saprolite that overlies competent bedrock, which formed from very well-weathered and decomposed rock (either diabase or mudstone of the Lockatong Formation). The saprolite grades upward into the Raritan Fire Clay without a distinct contact. The saprolite appears to be laterally continuous across the site and is typically up to five feet thick.

Site Hydrogeology

The upper water bearing unit at the Refinery is an unconfined shallow water bearing zone that is present within the fill layer. A middle water bearing zone is present within the glacial outwash deposits. The lower water bearing unit is the Farrington Sand, which has been used in the past in the Perth Amboy area as a local public water supply source, or drinking water source unit, but is no longer used for these purposes.

In the northern and eastern areas of the Refinery, the upper water bearing zone in the fill is separated from the water bearing zones in the glacial outwash and Farrington Sand (where present) by the organic clay unit. In the southern and western areas of the Refinery, the organic clay unit pinches out and the water bearing zone in the fill is underlain by the glacial till, or glaciolacustrine clays. The Farrington Sand is further isolated from groundwater within the fill by the Woodbridge Clay. The low permeability clays and silts that separate the permeable water bearing zones are discontinuous.

In general, groundwater is encountered at depths ranging from two feet bgs in the low lying areas of the Refinery, to an approximate maximum depth of 10 feet bgs in the areas of higher elevation. Site data indicate that hydraulic communication between the permeable zones is limited where the intervening low permeability units are present. Historical water level elevations from nested or closely spaced wells screened in the shallow and deep zones vary by as much as four feet. Groundwater flow direction also varies between the zones. Based on limited historical data, the groundwater in the Farrington Sand beneath the Refinery generally flows to the east or southeast, which is similar to the regional flow pattern.

Recent potentiometric data from well pairs, consisting of one well screened across the water table and one well screened below the water table, indicate that there is an upward hydraulic gradient from the native clays and glacial units below the fill towards the water bearing unit in the fill. This upward gradient probably limits the downward migration of dissolved contaminants in the groundwater.

Tidally influenced groundwater level fluctuations and saltwater intrusion into the shallow water bearing zone have been observed and documented in the areas near Woodbridge Creek. Data from wells in the NFB area have shown a tidally related groundwater elevation fluctuation of up to 1.5 feet. In contrast, monitoring wells in the EYB area have shown little tidal influence. This limited tidal influence in the East Yard is attributed to the bulkheads that have been placed along the Arthur Kill. Saltwater intrusion into the Farrington Sand has been documented in the area south of Woodbridge Creek at and near the Refinery.

9.2 Environmentally Sensitive Natural Resources

Pursuant to Section 1.8 of the TRSR, environmentally sensitive natural resources include wetlands, groundwater, surface water and other areas (see Table 9-1). For this BEE, groundwater is evaluated as a potential migration pathway only. According to Section 4.7 of the TRSR, ecological assessment of groundwater as a receptor is not required.

Table 9-1. Environmentally Sensitive Area Review

Environmentally Sensitive Area (as per N.J.A.C. 7:1E-1.8)	Presence at or Immediately Adjacent to Site
Surface waters	Yes (Arthur Kill, Spa Spring Creek and Woodbridge Creek)
Sources of water supply	No
Bay islands and barrier island corridors	No
Beaches	No
Dunes	No
Wetlands and wetland transition areas	Yes
Breeding areas for forest area nesting species, colonial water birds or aquatic furbearers	Potentially yes (Arthur Kill and Woodbridge Creek)
Migratory stopover areas for migrant shorebirds, raptors or passerines	Potentially yes (Woodbridge Creek)
Wintering areas (including coastal tidal marshes and water areas), waterfowl concentration areas and Atlantic White Cedar stands	Potentially yes (Arthur Kill)
Prime fishing areas	No
Finfish migratory pathways	Yes
Special submerged vegetation areas	No
Shellfish harvesting waters	No
Forest areas (prime and unique forest land)	No
Federal and State-listed threatened or endangered species	No
Federal and State wilderness areas	No
Federal and State Wild and Scenic River	No

In addition to a site inspection (summarized below), the following sources of information were used to evaluate whether any environmentally sensitive natural resources are on or immediately adjacent to the Project site:

- Perth Amboy U. S. Geological Survey (USGS) Topographic Quadrangle Map.
- NJDEP, Perth Amboy SE, Freshwater Wetlands Map.
- U.S. Department of Interior (USDOI). National Wetlands Inventory, Perth Amboy Quadrangle.
- NJDEP's GIS - 1995/1997 version.
- USDOI Fish and Wildlife Service Correspondence. March 15, 1999.
- NJDEP Office of Natural Lands Management for a Natural Heritage Program. Correspondence dated March 24, 1999.
- BCM Engineers' Letter of Interpretation Request. Chevron U.S.A., Inc. RCRA Closure Perth Amboy Refinery. March 1990.
- Chevron Perth Amboy Refinery, *Description of Current Conditions, Vol. 1*. August 26 1994.
- Chevron Products Company Perth Amboy, NJ. *Request for Renewal of Waterfront Development Permit No. 1216-90-0001.3, Freshwater Wetlands Transition Area Waiver No. 1216-90-0001.5 and Freshwater Wetlands Letter of Interpretation No. 216-90-0001.2 - FWLI Request for Re-authorization Under Freshwater Wetlands Statewide General Permit No. 6*. December 26, 1996.
- Chevron. *1st-Phase RFI Soils Report*. January 1997.
- Foster Wheeler Environmental Corporation. *Preparedness, Prevention and Contingency Plan Volume B (Addendum to Volume B) for Chevron Products Company*. May 1999.
- Chevron. *West Yard Baseline Ecological Evaluation*. April 19, 2001.
- Chevron Environmental Management Company Perth Amboy, New Jersey. *Refinery Quarterly Progress Report*. June 2001 (Report No. CA00-2, CA00-3, and CA00-4).
- Chevron. *Full RCRA Facility Investigation Workplan*. October 2001.
- Chevron Environmental Management Company Perth Amboy, New Jersey. *Refinery Quarterly Progress Report*. December 2001 (Report No. CA01-1 and CA01-2).
- Chevron Environmental Management Company Perth Amboy, New Jersey. *Refinery Quarterly Progress Report*. August 2002. (Report No. CA01-3 and CA01-4).

- DRAI. *Health and Safety Plan Module for Sediment and Surface Water Investigation Arthur Kill, Woodbridge Creek and Spa Spring Creek*. December 10, 2002.
- Chevron U.S.A. Perth Amboy, New Jersey. *RCRA Corrective Action Project Stabilization Measures Status Report*. January 2003. (3rd Quarter 2001 and 4th Quarter 2001 Reports).
- Chevron. *Refinery Quarterly Progress Report – 3rd and 4th Quarter 2002* (Reporting period: July 1, 2002 – December 31, 2002). April 7, 2003.

The identification of environmentally sensitive areas based on a review of the above-referenced sources is discussed below.

9.2.1 USGS Topographic Quadrangle

Based on the USGS Perth Amboy, NJ-NY Topographic Quadrangle (Figure 9-1), the nearest surface water bodies are the Arthur Kill, located adjacently east of the site; Spa Spring Creek, located adjacently north of the site; and Woodbridge Creek, located adjacent and northeast of the site. The regional topography slopes gently downward to the east. Local and site surface drainage is to the northeast, and is controlled by excavated storm drainage swales, ditches and culverts. Stormwater runoff from the former process plants on the site generally flows into the OWSS.

9.2.2 Wetlands Maps

The following wetlands maps were reviewed as part of the BEE to identify wetland areas that are present on and adjacent to the site:

- NJDEP's Freshwater Wetlands Map for southeast Perth Amboy, New Jersey - New York Quadrangle (Figure 9-2);
- USDOI's National Wetlands Inventory Map for Perth Amboy (Figure 9-2); and
- Site-specific wetland delineation maps prepared for letters of interpretation as described in Section 2.0 (Figure 9-3).

The following descriptions of the wetland maps include information obtained from field observations made in the site-specific wetland delineation (Section 2.0) and the BEE site inspection (Section 9.2.6).

9.2.2.1 NJDEP Wetland Map

The NJDEP's Freshwater Wetlands Map for the Southeast Perth Amboy, New Jersey – New York Quadrangle (Figure 9-2) classifies the majority of the site as upland (i.e., non-wetlands). The map depicts three on-site wetland areas in the northeast and east portions of the site, and two wetland areas that are present along the north, northeast and east property lines. The two on-site areas in the northeast are classified as permanent palustrine

diked/impounded open water. These features are the NFB and the Surge Pond, which are regulated surface impoundments currently being closed under an NJPDES permit. The third on-site area, located in the East Yard near the waterfront, is identified as a permanent palustrine excavated open water. This feature is the EYB, which is also a regulated surface impoundment being closed under the NJPDES permit.

The two wetlands areas located along the north, northeast and eastern property lines include a lower perennial riverine system with an unconsolidated mud bottom along the northern property boundary (Spa Spring Creek) and unclassified subtidal, intermittently flooded wetlands along the northeast property line (Woodbridge Creek) and east of the site (Arthur Kill).

9.2.2.2 USDOI Wetlands Map

Four wetland areas are identified on the USDOI's National Wetlands Inventory Map for Perth Amboy (Figure 9-2). A large area is identified as an open water palustrine system with an unknown bottom in the northern portion of the site adjacent to Woodbridge Creek. This area comprises the NFB and Surge Pond, which are in the process of being closed, as described above.

Both the Arthur Kill to the east and Woodbridge Creek northeast of the site are designated as estuarine subtidal open waters. The area of the Arthur Kill adjacent to the East Yard bulkhead is classified as an estuarine intertidal flat. A palustrine intertidal wetland area with emergent vegetation is also identified on the south bank of Woodbridge Creek northeast of the Central Yard.

9.2.2.3 Site-Specific Wetland Delineation

Based on previous investigations summarized in Section 2, a 3.2-acre intermediate resource value estuarine intertidal emergent wetland is present adjacent to Spa Spring Creek and Woodbridge Creek, along the north and northeast property lines (Figure 9-3).

9.2.3 NJDEP Geographical Information System

The NJDEP's 1995/1997 GIS database was reviewed to identify environmentally sensitive natural resources. The NJDEP's GIS database includes geo-coded files that represent types of land use and land cover for the entire state. The available GIS land use/land cover areas and types reviewed for this BEE are included on Figure 9-4.

The NJDEP's GIS database identifies the majority of the project area site as industrial and urban/built-up land. Environmentally sensitive areas on or adjacent to the site include creeks, surface tidal waters and artificial lakes the north, northeast and east. The land use in the vicinity of the site is largely industrial. In general, the wetland areas identified in the GIS database correspond to the wetland areas shown on the NJDEP and USDOI Wetland Maps.

9.2.4 NJDEP's Natural Heritage Program Database

Foster Wheeler Environmental Corporation of Livingston, New Jersey, submitted a request to the NJDEP Office of Natural Lands Management for a Natural Heritage Program database review of threatened or endangered plant and animal species known to exist on-site or in the surrounding area. The NJDEP issued a response letter dated March 24, 1999 indicating that there are no records in the database of any rare plants, animals or natural communities in the vicinity of the site. A copy of the NJDEP Natural Heritage Program database correspondence is included as Appendix H.

9.2.5 U.S. Fish and Wildlife Service

Foster Wheeler Environmental Corporation submitted a request to the USDOJ Fish and Wildlife Service for a review of the site pursuant to the Endangered Species Act (ESA) of 1973. According to the U.S. Fish and Wildlife Service, there are two documented occurrences of swamp pink (*Helonias bullata*), a federally listed threatened plant species. Based on the site inspection, spartina grass and phragmites dominate the wetland areas at the confluence of Spa Spring Creek and Woodbridge Creek. In addition to swamp pink, the peregrine falcon (*Falco peregrinus*), a federally listed endangered species, nests within the 15-mile study area. There is also the occasional transient bald eagle (*Haliaeetus leucocephalus*), a federally listed threatened species that may occur in the study area. However, the study area is a radius of 15 miles and the threatened and endangered species described are not expected to occur on or adjacent to the site. A copy of the U.S. Fish and Wildlife Service correspondence dated March 15, 1999 is included as Appendix I.

9.2.6 BEE Site Inspection

TRC Raviv conducted an inspection of the site and surrounding properties on June 12, 2003. The purpose of the inspection was to provide field verification of the wetland maps, and identify any additional environmentally sensitive areas and evidence of potential impacts such as stressed/dead vegetation, discolored soil/sediment, sheens on surface water, or the presence of seeps and discharges. All on-site and adjacent surface waters and wetland areas identified at the site were included in the inspection. Photographs taken during the site inspection are included as Appendix J.

Site Inspection Summary

TRC Raviv inspected the wetland areas surrounding the Refinery, particularly along the Arthur Kill, Spa Spring Creek and Woodbridge Creek. In general, the wetland areas inspected appear to be consistent with the federal and state wetland map descriptions, including estuarine, intertidal wetlands, open water palustrine wetlands and lower perennial riverine system wetlands.

The inspection was conducted during low tide and mud flats were exposed along the banks of the creeks. Communities of spartina and phragmites dominate the wetland vegetation in the

wetland areas inspected. Wildlife observed during the inspection included mallards and egrets that were present at a few locations near the banks of Woodbridge Creek.

Small amounts of miscellaneous solid waste (e.g., tires, clothing, plastic, wood, etc.), apparently transported and deposited from off-site sources by tidal flow, were observed throughout the adjacent wetland areas along Woodbridge Creek. However, there was no evidence of stressed or dead vegetation along the banks of Spa Spring Creek and Woodbridge Creek, and no sheens were observed on the water surface at the time of the inspection. However, a small water seep was observed on the southeast corner of the concrete secondary wastewater treatment unit.

The ground surfaces along the banks of Spa Spring and Woodbridge Creeks were either paved or a berm was present to direct runoff away from the stream channels and toward the site. In some areas of the Refinery boundary, especially around Spa Spring Creek, vegetated buffers exist along the bank between the Refinery roadway and the stream bed. There was no evidence of stormwater runoff (e.g., erosion channels, ditches or discrete conveyances) observed anywhere along the creek banks on the Refinery site at the time of the inspection.

The site boundary to the east that borders the Arthur Kill is comprised of a bulkhead and shipping terminal dock. Steel sheet piling is visible at the surface for much of the property line that forms the contact with the water's edge. The southern area of the wooded wharf appears to be failing, and some minor local erosion of soil has occurred. However, there is no evidence of any discharges from this area to the Arthur Kill, such as oily sheens, staining or discoloration.

9.2.7 Conclusions

Based on the above review, environmentally sensitive areas are present adjacent to the site, including small areas of intertidal estuarine wetlands and open water palustrine systems associated with Spa Spring Creek and Woodbridge Creek located to the north and northeast, and the Arthur Kill, located to the east of the site.

Although miscellaneous solid waste that appears to have been deposited from tidal flow was observed throughout the wetland areas, there was no evidence of stressed or dead vegetation along the banks of Spa Spring Creek and Woodbridge Creek, and no sheens were observed on the water surface in any of the water bodies adjacent to the site at the time of the inspection.

9.3 Contaminants of Potential Ecological Concern

In accordance with Section 3.11(a)1 of the TRSR, COPECs include substances that exhibit the ability to biomagnify, bioaccumulate, or that exceed available ecological criteria or guidelines. To identify COPECs, TRC Raviv reviewed existing soil, groundwater, surface water and sediment data that are available for the site from prior and recent investigations. These data, which were included in Chevron's October 2001 *Full RCRA Facility*

Investigation Workplan and the other documents listed in Section 9.2, were summarized and evaluated to identify COPECs in the following sections.

9.3.1 SWMUs and AOCs Located Adjacent to Environmentally Sensitive Areas

There are 44 SWMUs and 35 AOCs within the North Field/Main Yard, Central Yard and East Yard areas of the Chevron Refinery, most of which are located interior to the site boundaries. The SWMUs and AOCs that are adjacent to the surface water bodies that border the property are listed below.

North Field

The North Field area of the Refinery is bordered by Spa Spring Creek to the north and by Woodbridge Creek to the east. The SWMUs and AOCs that are located adjacent to Spa Spring Creek in the North Field area include:

- SWMU 27: TEL Weathering Area;
- SWMU 28: Reactor Burial;
- SWMU 29: Fines Transfer Area;
- SWMU 30: Short-Term Storage Area;
- SWMU 38: North Field Slop Pond;
- SWMU 39: Unnamed North Field Pond;
- AOC 5: Petroleum Substance Near Former UST E3; and
- AOC 7: Tarry Material at MW-13

The SWMUs in the North Field area that are located adjacent to Woodbridge Creek include:

- SWMU 1: North Field Basin;
- SWMU 2: Surge Pond;
- SWMU 7: TEL Burial – 2 Burials (southeast of Tank 305);
- SWMU 24: TEL Weathering Area (east of Tank 9209, south of the ETP);
- SWMU 31: Effluent Treatment Plant;
- SWMU 40: Old Pond; and
- SWMU 41: Drying Area.

No AOCs are identified adjacent to Woodbridge Creek.

East Yard

The East Yard area of the Refinery is bordered by the Arthur Kill to the east. The SWMUs and AOCs that are located adjacent to the Arthur Kill in this area include:

- SWMU 25: TEL Weathering Area (north of East Yard Basin);
- SWMU 26: TEL Weathering Area (south of East Yard Basin);
- SWMU 36: Oil/Water Separator near East Yard Basin;
- AOC 13: B-11 Oily Fill Area; and
- AOC 29: 5 Berth Area.

9.3.2 Soil

The soil data described in Section 6 were used to develop an initial list of site-related COPECs by identifying those hazardous substances detected in the on-site soils at concentrations above the RFI Soil Delineation Criteria. A summary of the soil sample analytical results is included on Table 6-2, along with total numbers of analyses per constituent and the percentage of the samples exceeding the delineation criteria.

The following summary (Table 9-2) is limited to the constituents in soils found at concentrations above the delineation criteria that were also detected in sediment and/or surface water samples above their respective ecological screening criteria (see Section 9.3.5):

Table 9-2. Constituents Found in Soils and Sediment or Surface Water Above Criteria

Parameter (mg/kg)	Maximum Concentration in Soil	% of Samples Exceeding Criteria	Delineation Criteria
VOCs			
Benzene	26,000	12%	1
Ethylbenzene	160,000	1%	100
Toluene	9,700	1%	500
Xylenes	220,000	4%	67
SVOCs			
Benzo(a)anthracene	54	10%	0.9
Benzo(a)pyrene	71	12%	0.66
Benzo(b)fluoranthene	40	8%	0.9
Benzo(k)fluoranthene	19	2%	0.9
Chrysene	86	0.1%	62
Dibenz(a,h)anthracene	4.9	2%	0.66
Indeno(1,2,3-cd)pyrene	11	3%	0.9
Naphthalene	450	1%	100
Pyrene	110	0.1%	100

Table 9-2. Constituents Found in Soils and Sediment or Surface Water Above Criteria

Parameter (mg/kg)	Maximum Concentration in Soil	% of Samples Exceeding Criteria	Delineation Criteria
Metals			
Antimony	228	5%	14
Arsenic	117	15%	20
Copper	3,450	3%	600
Lead	145,000	11%	400
Mercury	29	0.2%	14
Nickel	3,080	2%	250
Zinc	10,500	1%	1,500

It should be noted that the calculations for percent of samples exceeding the delineation criteria are based on a robust data set, with the total numbers of soil analyses ranging from 369 to 744 analyses per constituent. Based on the soil data, the substances listed in the table above were all detected at low frequencies (i.e., less than 15 percent). Of the 20 substances listed, only seven were found above the delineation criteria at detection frequencies above 5%. Four organic compounds (benzene, benzo(a)anthracene, benzo(a)pyrene and benzo(b)fluoranthene) were detected above the delineation criteria in more than 5 percent of soil samples. Three metals (antimony, arsenic and lead) were detected above the delineation criteria in more than 5 percent of soil samples.

Based on Section 6, all contaminated soil areas in SWMUs and AOCs located adjacent to environmentally sensitive areas (i.e., adjacent surface water and wetlands) have been delineated. Soil contamination does not appear to extend into the nearby water bodies in any of these areas. Potential migration pathways, such as surface erosion of soils, are evaluated in Section 9.6.

9.3.3 Groundwater

The groundwater data described in Section 8 was used to develop an initial list of site-related COPECs by identifying those hazardous substances detected in the on-site groundwater at concentrations above the RFI groundwater delineation criteria. A summary of the groundwater sample analytical results is included on Table 9-3, along with total numbers of analyses per constituent and the percentage of the samples exceeding the criteria.

Table 9-3. Summary of COCs Detected in Groundwater Above Criteria

COC Detected Above Delineation Criteria (µg/L)	Full RFI Delineation Criteria	Sitewide			
		Maximum Concentration Detected	Number of Exceedances	Number of Samples	% Exceeded
Volatiles					
1,1,1-Trichloroethane	30	2,100	3	201	1.5%
1,1-Dichloroethane	70	75	1	201	0.5%
1,1-Dichloroethene	2	220	8	201	4.0%
1,2-Dibromoethane	0.05	5	1	191	0.5%
1,2-Dichloropropane	1	7	1	201	0.5%
1,4-Dichlorobenzene	75	250	1	211	0.5%
Benzene	1	6,300	58	220	26.4%
Bromodichloromethane	1	6	1	201	0.5%
Chlorobenzene	4	580	2	201	1.0%
Chloroform	6	24	1	201	0.5%
cis-1,2-Dichloroethene	10	88	3	201	1.5%
Cyclohexane	100	930	13	191	6.8%
Ethylbenzene	700	3,600	5	220	2.3%
methyl t-butyl ether	70	240	3	191	1.6%
Methylcyclohexane	100	370	5	191	2.6%
Tetrachloroethene	1	37	4	201	2.0%
Toluene	1,000	6,500	3	220	1.4%
Trichloroethene	1	1,400	5	201	2.5%
Vinyl chloride	5	21	2	201	1.0%
Xylene (total)	1,000	25,000	12	220	5.5%
Semi-Volatiles					
2,4-Dimethylphenol	100	55,000	6	201	3.0%
2-Methylnaphthalene	100	180	3	191	1.6%
2-Methylphenol	100	77,000	3	191	1.6%
4-Methylphenol	100	87,000	3	191	1.6%
Benzo(a)anthracene	0.2	24	6	211	2.8%

Table 9-3. Summary of COCs Detected in Groundwater Above Criteria

COC Detected Above Delineation Criteria (µg/L)	Full RFI Delineation Criteria	Sitewide			
		Maximum Concentration Detected	Number of Exceedances	Number of Samples	% Exceeded
Benzo(a)pyrene	0.2	39	6	211	2.8%
Benzo(b)fluoranthene	10	19	1	211	0.5%
Benzo(k)fluoranthene	1	4	2	211	0.9%
bis(2-Ethylhexyl)phthalate	30	560	7	211	3.3%
Caprolactam	100	270	5	191	2.6%
Carbazole	5	11	1	191	0.5%
Chrysene	5	36	3	216	1.4%
Dibenz(a,h)anthracene	0.5	9	7	211	3.3%
Indeno(1,2,3-cd)pyrene	10	11	1	211	0.5%
Naphthalene	300	550	4	220	1.8%
N-Nitrosodiphenylamine	20	73	2	211	0.9%
Pentachlorophenol	1	14	1	191	0.5%
Phenol	4,000	18,000	2	191	1.0%
Metals					
Aluminum	200	6,550	49	182	26.9%
Antimony	20	69.2	2	182	1.1%
Arsenic	8	408	52	192	27.1%
Cobalt	100	548	9	182	4.9%
Lead	10	172	19	212	9.0%
Manganese	50	37,800	174	182	95.6%
Nickel	100	400	11	204	5.4%
Thallium	10	126	19	182	10.4%

Indicator COCs and maximum concentrations are highlighted in bold.

If % of exceedances is 5% or greater, the number is also highlighted in bold.

The following summary (Table 9-4) is limited to the constituents in groundwater found at concentrations above the delineation criteria that were also detected in sediment and/or surface water samples above their respective ecological screening criteria (see Section 9.3.5):

Table 9-4. Constituents Found in Groundwater and Sediment or Surface Water Above Criteria

Parameter (µg/L)	Maximum Concentration in Groundwater	% of Samples Exceeding Criteria	Delineation Criteria
VOCs			
Benzene	6,300	26.4%	1
Ethylbenzene	3,600	2.3%	700
Xylenes	25,000	5.5%	1,000
SVOCs			
2-Methylnapthalene	180	1.6%	100
Benzo(a)anthracene	24	2.8%	0.2
Benzo(a)pyrene	39	2.8%	0.2
Benzo(k)fluoranthene	4	0.9%	1
Chrysene	36	1.4%	5
Debenz(a,h)anthracene	9	3.3%	0.5
Indeno(1,2,3-cd)pyrene	11	0.5%	10
Naphthalene	550	1.8%	300
Metals			
Antimony	69.2	1.1%	20
Arsenic	408	27.1%	8
Lead	172	9.0%	10
Nickel	400	5.4%	100

The percentages of samples exceeding the delineation criteria are calculated based on a relatively large data set, with total numbers of groundwater analyses ranging from 182 to 220 analyses per constituent collected over the past two years. Based on the groundwater data, the substances listed in the table above were all detected at moderately low frequencies (i.e., less than 28 percent). Of the 15 substances listed, only five were found above the delineation criteria at detection frequencies above 5 percent. Two VOCs (benzene and xylene) were detected above the delineation criteria in more than 5 percent of groundwater samples. Three metals (arsenic, lead and nickel) were detected above the delineation criteria in more than 5 percent of the samples.

Nearly all of the groundwater samples containing elevated constituent concentrations were collected from monitoring wells that are not located near the surface water bodies adjacent to the site. As described in Section 8, the groundwater quality in the sentinel wells located adjacent (i.e., immediately upgradient) to the off-site water bodies is generally within the delineation criteria for the monitoring parameters analyzed.

The constituents detected in the fourth quarter 2002 groundwater samples at concentrations above the delineation criteria, that are also identified at elevated concentrations in sediment and/or surface water samples (see Section 9.3.5), are presented on Figure 9-5. Based on the distribution of sample locations where these substances appear at elevated concentrations, the groundwater does not generally appear to be impacted in areas close to the surface water bodies. Elevated concentrations of benzene, arsenic and/or nickel were detected in groundwater samples collected during the fourth quarter 2002 sampling round from four monitoring wells (Table 9-5):

Table 9-5. Fourth Quarter 2002 Groundwater Exceedances

MW Number	AOC/SWMU	Constituent	Concentration (µg/L)
MW-13	AOC 7	Arsenic	16.1
MW-13	AOC 7	Nickel	314
NF-13	SWMU 1	Nickel	163
MW-124	SWMU 24	Arsenic	8.7
MW-155	AOC 29	Benzene	2

These data are evaluated further for comparison with sediment and surface water quality data in Section 9.3.5. However, it should be noted that these concentrations are relatively low and do not suggest a significant potential for off-site contribution of arsenic, nickel or benzene to off-site receptors in the vicinity of the individual well locations.

9.3.4 LNAPL

Based on Chevron's September 23, 2002 *LNAPL Management Plan*, an LNAPL Investigation was conducted as described in Section 7. Based on that investigation, LNAPL was found in 17 areas at the Refinery. However, none of the LNAPL areas intersect any of the environmentally sensitive areas identified adjacent to the site.

9.3.5 Sediments and Surface Water Sample Collection and Analysis

TRC Raviv collected sediment and surface water samples from the Arthur Kill, Spa Spring Creek and Woodbridge Creek on December 17, 18, 19 and 20, 2002. The purpose of the sampling was to characterize the sediments and surface water in the Arthur Kill and the two creeks, characterize background conditions, and evaluate potential impacts from the adjacent Refinery. Forty-two sediment and 17 surface water samples were collected in accordance with NJDEP's *Field Sampling Procedures Manual* and the TRSR (TRSR; NJAC 7:26E). All of the surface water samples were collected near the sides of the creek channels. Sediment samples were collected from both sides and the middle of the creek. The sediment samples obtained from the sides of the creek were collected from depositional zones.

Lancaster Laboratories of Lancaster, Pennsylvania, a New Jersey-certified laboratory, analyzed all of the samples. All sediment samples were analyzed for TCL VOCs, TCL SVOCs, TAL metals, TOL, nitrate, nitrite, TKN, ammonia, TOC, pH and particle grain size.

All surface water samples were analyzed for TCL VOCs, TCL SVOCs, total TAL metals, dissolved TAL metals, total hardness (as CaCO_3), TSS, turbidity, chlorides, nitrate, nitrite, TKN, ammonia and sulfate.

Sediments

Sediment samples were collected by EEA, Inc. of Garden City, New York using boat-mounted vibratory coring (vibracore) equipment. Sampling in the Arthur Kill was completed using a 55-foot R/V Walford equipped with a pneumatic vibracore device. A 19-foot Carolina skiff with a forward mounted A-frame and Rossfelded P-1 electric vibratory corer was used to obtain sediment samples from Woodbridge and Spa Spring Creeks.

The vibracore sampler consists of an electric or pneumatic vibratory head that drives a three-inch diameter, eight-foot stainless steel core barrel lined with a dedicated six-mil HDPE liner. During sampling, the liners are extruded and cut open for processing and new liners are installed prior to collecting each core.

Vibracore sediment samples were collected from each of three locations along each transect, unless otherwise noted below. One vibracore was collected in the middle of the creek and two were collected on either side of the creek within depositional zones. Samples collected from the side of the creek opposite the Refinery were designated "A", those collected from the middle "B", and those adjacent to the Refinery "C". In the Arthur Kill, vibracores were only collected on the Refinery (C) side of the Kill.

Vibracores were advanced into the Arthur Kill sediments to a depth of 12 feet below the top of sediment or until refusal, whichever came first. Vibracores were advanced into Woodbridge Creek and Spa Spring Creek sediments to a depth of eight feet below the top of sediment or until refusal, whichever came first. Refusal is defined as the point at which the vibratory sampler cannot penetrate the sediments any further due to dense subsurface conditions.

Twenty-nine sediment samples were obtained from Woodbridge Creek Transects SED-1, 2, 3, 4, 5, 6, 9 and 10; six sediment samples were obtained from Spa Spring Creek Transects SED-7, 8 and 11; and seven sediment samples were collected from Arthur Kill Transects SED-13, 14, 15, 16, 17 and 18 (Figures 9-6, 9-7 and 9-8). Sediment samples were collected from three locations at most creek transects, including the side closest to Chevron (C), opposite side of the creek (A) and center of the creek (B). At each location, samples were collected from the zero to six-inch interval below the sediment surface (bs), six to 12-inch interval bs, or both. Additional sediment samples were collected at deeper intervals in some locations, based on field observations.

Prior to disturbing the core, a TCL VOC sample was collected from the six to 12 inch interval of each vibracore using methanol extraction/preservation. The sediment cores were then visually inspected and field screened using a photo-ionization detector (PID). When evidence of contamination appeared deeper within the vibracore, additional samples were

collected at those intervals. Additional samples were collected at SED-3-C, SED-4-A and SED-9-C.

Vibracore samples were not collected at sampling locations SED-11-A and SED-8-B due to refusal of the vibratory sampler at the sediment surface. A vibracore sample was not attempted at the SED-11-B location due to the narrowness of the stream. Also, transect 11 was relocated to the east side of the railroad bridge due to obstructions that would not allow the boat and crew to pass underneath the bridge. Vibracore logs are attached in Appendix D.

As part of this review, the sediment analytical results were compared to criteria provided in the NJDEP's 1998 *Guidance for Sediment Quality Evaluations* (GSQE). The GSQE includes Marine/Estuarine Sediment Screening Guidelines (SSG) for selected VOCs, PAHs, PCBs, pesticides and metals in sediment. The SSG are divided into two groups: effects range-low (ER-L), which represent concentrations at which adverse benthic impacts are found in approximately 10 percent of studies, and effects range-median (ER-M), which represent concentrations at which adverse benthic impacts are found in approximately 50 percent of studies. In accordance with the GSQE, the ER-L was used to screen the sediment data for this BEE. However, the GSQE allows for a "weight-of-evidence/professional judgment" approach when evaluating sediment data that exhibit concentrations marginally higher than ER-L. Therefore, the ER-M is included to provide a reference for evaluating the significance of sediment sample concentrations that are above ER-L.

The maximum values for contaminants detected above ER-L in the sediment samples are provided below (Table 9-6), with the respective ER-L and ER-M and frequency of detection above the ER-L. The sediment data is presented on Tables 9-7 through 9-11 (presented at the end of this section), and Figures 9-6 through 9-8.

Table 9-6. Maximum Sediment Concentrations

Parameter (mg/kg)	Maximum Concentration	NJDEP SSG		Samples >ER-L Per Total
		ER-L	ER-M	
VOCs				
Benzene	20	0.34	CV	4/42
Ethylbenzene	6.6	1.4	CV	3/42
Toluene	2.9	2.5	CV	1/42
Xylene (total)	29	0.12	CV	5/42
SVOCs				
2-Methylnaphthalene	39	0.07	0.67	10/42
Acenaphthene	3.9	0.016	0.5	30/42
Acenaphthylene	1.2	0.044	0.64	28/42
Anthracene	3.1	0.085	1.1	29/42
Benzo(a)anthracene	6.5	0.261	1.6	30/42
Benzo(a)pyrene	13	0.43	1.6	29/42
Benzo(g,h,i)perylene	18	0.17	320	33/42

Table 9-6. Maximum Sediment Concentrations

Parameter (mg/kg)	Maximum Concentration	NJDEP SSG		Samples >ER-L Per Total
		ER-L	ER-M	
Benzo(k)fluoranthene	1.3	0.24	1,340	27/42
Chrysene	11	0.384	2.8	29/42
Dibenzo(a,h)anthracene	4	0.063	0.26	29/42
Fluoranthene	6.4	0.6	5.1	29/42
Fluorene	5.8	0.019	0.54	29/42
Indeno(1,2,3-cd)pyrene	4.1	0.2	320	29/42
Naphthalene	10	0.16	2.1	7/42
Phenanthrene	18	0.24	1.5	25/42
Pyrene	13	0.665	2.6	30/42
Total PAHs	140.57	4	45	31/42
Metals				
Antimony	7.9	2	25	7/42
Arsenic	164	8.2	70	35/42
Cadmium	13	1.2	9.6	28/42
Chromium	198	81	370	16/42
Copper	8030	34	270	37/42
Lead	656	47	218	34/42
Mercury	7	0.15	0.71	30/42
Nickel	2480	21	52	41/42
Silver	7.9	1	3.7	22/42
Zinc	2970	150	410	35/42

CV = Chronic Value SSG

Chemical constituents exceeding ER-Ls were detected in background sediment sample locations, as well as locations adjacent to the Refinery. Also, staining and/or petroleum odors were noted in sediment cores at several locations, including in several potential background locations in Woodbridge Creek sediment samples obtained from sampling transects SED-09 and SED-10 (see Vibracore Logs in Appendix D). However, stained sediments were not observed in any of the Arthur Kill cores. The presence of stained sediments is noted on Figures 9-6, 9-7 and 9-8 for samples that also exhibited elevated contaminant concentrations.

BTEX compounds were the only VOC constituents detected at elevated concentrations in both the off-site sediments and in on-site groundwater samples. However, BTEX compounds were detected at a very low frequency in the sediment (two to 11 percent). Benzene was only found in four sediment samples, ethylbenzene was only detected in three sediment samples, toluene was only found in one sediment sample, and xylenes were found in five of the 42 sediment samples.

Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, 2-methylnaphthalene, naphthalene, phenanthrene and pyrene were SVOCs detected at elevated concentrations in both the off-site sediments and on-site groundwater or soil samples.

2-Methylnaphthalene and naphthalene were detected at a relatively low frequency (15 to 24 percent). The remaining SVOC constituents were detected at a higher frequency in the sediment (62 to 71 percent). However, the detection frequencies for VOCs and SVOCs in on-site soils and groundwater are low. Only benzene and xylenes were detected at a frequency above 5 percent in groundwater. Also, the only compounds that exhibit a detection frequency above 5 percent in soils include benzene, benzo(a)anthracene, benzo(a)pyrene and benzo(b)fluoranthene.

Silver, arsenic, cadmium, copper, mercury, lead, nickel and zinc were detected at a relatively high frequency in the sediment (52 to 95 percent); antimony and chromium were detected at a lower frequency (13 to 32 percent). However, only arsenic, nickel and lead were also found at elevated concentrations in on-site groundwater samples at detection frequencies above 5 percent. In addition, arsenic, lead and antimony were the only metals that were also detected at elevated concentrations in on-site soils at frequencies above 5 percent.

Surface Water

Most of the surface water samples were collected from the sediment sampling boats using laboratory-provided glassware. All surface water samples were collected prior to sediment sample collection to avoid disturbing the water column. Surface water samples were collected from the Arthur Kill on December 17, 2002, between 11:00 a.m. and 3:00 p.m., during ebb tide.

With the exception of SW-10-C, the surface water samples were collected on December 18, 2002, during ebb tide between 8:55 a.m. and 3:45 p.m., starting from downstream locations in Woodbridge Creek continuing towards upstream locations. After collecting surface water sample SW-9-C at Transect 9, the tide was too low to navigate further upstream in Woodbridge Creek or upstream in Spa Spring Creek. Surface water samples from Spa Spring Creek were collected by hand due to the shallow water conditions (0.5 to 1 foot deep water). Surface water sample SW-10-C was collected at high tide the following day (December 19, 2002) at 9:25 a.m. Due to the high tide, Transect 10 was relocated to the south side of the New Jersey Turnpike. The boat and crew could not fit under the bridges. All sampling locations are tidally influenced.

The VOC sample was collected first at each location using a Van-Dorn water sampler approximately one foot above the top of sediment to avoid disturbing the water column. A Van-Dorn water sampler is capable of collecting a sample from a discrete interval. After collecting the VOC sample, a peristaltic pump was used to collect samples for the remaining parameters. Weighted Teflon® tubing was placed approximately one foot above the top of sediment and the samples were pumped directly into the sample jars. Dedicated, disposable Teflon® and Masterflex® tubing were used at each sample location.

Eight surface water samples (SW-1, 2, 3, 4, 5, 6, 9 and 10) were collected from Woodbridge Creek, three (SW-7, 8 and 11) from Spa Spring Creek, and six (SW-13, 14, 14d, 15, 16 and 17) from the Arthur Kill (Figure 9-9). Lancaster Laboratories analyzed the samples for TCL VOCs, TCL SVOCs, total TAL metals, dissolved TAL metals, total hardness (as CaCO₃), TSS, turbidity, chlorides, nitrate, nitrite, TKN, ammonia and sulfate. The analytical results are presented on Tables 9-12 through 9-15 (presented at the end of this section) and Figure 9-9.

The surface water data were screened against the aquatic life protection criteria in NJDEP's Surface Water Quality Standards (SWQS) and the surface water criteria adopted by USEPA that are applicable in New Jersey, pursuant to the NJDEP's February 28, 2003 SWQS *Criteria for Toxic Pollutants Currently Applicable to New Jersey Surface Waters* memorandum. In addition, aquatic life protection criteria published in 1999 by the United States National Oceanic and Atmospheric Administration (NOAA) was used as ecological benchmarks when there were no SWQS or criteria published by USEPA or NJDEP.

The maximum values for contaminants detected above SWQC in the surface water samples are provided in Table 9-16 below, with the respective acute and chronic criteria, and frequency of detection above the SWQC.

Table 9-16. Maximum Surface Water Concentrations

Parameter (µg/L)	Maximum Concentration	SWQC		No. Samples > SWQC Per No. Samples
		Acute	Chronic	
Metals				
Mercury (unfiltered)	0.096	1.8	0.025	1/17
Nickel (filtered)	52.2	8.2	74	9/17
Zinc (filtered)	125	90	81	2/17

Of all the parameters analyzed in surface water samples obtained from the Arthur Kill and adjacent creeks, only three TAL metals were detected above the SWQC. Mercury was only detected above the SWQC in one sample (SW-14-C, Arthur Kill), at an estimated concentration of 0.096 µg/L. Nickel and zinc were detected in background surface water sample locations, as well as locations adjacent to the Refinery.

Based on a comparison of these data to the site soil and groundwater data, the only site-related constituent detected above the SWQC in the surface water samples is nickel, detected above the SWQC in 55 percent of the surface water samples. However, the highest nickel concentration (52.2 µg/L) was found in the Woodbridge Creek background sample location (SW-10-C).

Mercury and zinc are not present in on-site groundwater above the RFI Delineation Criteria, and were only detected in on-site soils at very low detection frequencies (see Section 9.3.3). Also, these two metals exhibit low frequencies of detection above the respective criteria in soil, groundwater, and surface water.

9.3.6 Conclusions

Based on the analytical results described above for the groundwater data and data from the sediments and surface water samples obtained from the adjacent creeks, the COPECs identified as potentially site-related include benzene, xylenes, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, arsenic, lead, nickel and antimony in sediment and nickel in surface water.

A brief discussion regarding the presence of these elements in sediments and surface water adjacent to the site is provided below. However, all of the hazardous substances listed here will be retained as COPECs for the BEE and included in the final BEE conclusions in Section 9.5.

9.3.6.1 Sediment

VOC Summary

Based on a comparison of the existing sediment data and the NJDEP's most current, stringent SSGs:

- Benzene and xylenes are COPECs in sediment, present at concentrations above the SSGs.
- VOCs are only found above SSGs in Woodbridge Creek sediments.
- VOCs exhibit a low frequency of detection above the SSG (five of 42 sediment samples).
- Sediment sample locations containing elevated VOCs generally coincide with sample locations containing elevated SVOCs.
- VOCs in sediments are not causing a contravention of the SWQC, based on the VOC surface water results.

SVOC Summary

- The SVOCs benzo(a)anthracene, benzo(a)pyrene and benzo(b)fluoranthene are COPECs in sediment, present at concentrations above the SSGs.
- Elevated SVOCs were found in more than 50 percent of the samples in all of the water bodies tested, including background locations.
- The distribution of SVOCs in the sediments likely represents the contribution of these substances from various sources, including off-site areas.
- The elevated SVOC concentrations in the surface water sediments are likely associated with historical contributions from many sources, rather than recent discharges.

- The presence of SVOCs in the sediment is not causing a contravention of the SWQC in the water column, based on the surface water analytical results.

In addition to analytical results, staining and/or petroleum odors were observed in several potential background locations in Woodbridge Creek sediment samples obtained from sampling transects SED-09 and SED-10 (see Vibracore Logs in Appendix D).

Metals Summary

Antimony is present at concentrations moderately above the ER-L, and well below the ER-M, in only six of the 42 sediment samples. Although only slightly elevated in sediment, these concentrations are approximately one order of magnitude below the concentrations of dissolved antimony in the site groundwater. In addition, antimony exhibits a very low detection frequency above the criterion, based on the site soil data.

Arsenic was detected in sediments at concentrations above the ER-L in 35 of 42 sediment samples. Only three of the 35 samples contained arsenic above the ER-M. Arsenic was also detected at elevated concentrations in background samples, and is present at a moderately high detection frequency in soil and groundwater. However, the source of arsenic is unknown, and it is potentially present due to regional, off-site sources that were historically present near the Refinery.

Cadmium was detected at concentrations moderately above the ER-L, and below the ER-M, in 31 of the 42 sediment samples. An elevated concentration of cadmium was detected in background sample SED-16-C (5.9 mg/kg). In addition, cadmium is not a COC in on-site soils and ground water. Therefore, off-site sources of cadmium are likely contributing to the elevated levels of cadmium in the sediment.

Chromium was detected at concentrations moderately above the ER-L, and well below the ER-M, in 15 of the 42 sediment samples. The highest chromium concentration was detected in background sample SED-16-C (198 mg/kg). In addition, chromium was not detected in the most recent site groundwater data. Therefore, off-site sources of chromium are likely contributing to the elevated levels of chromium in the sediment.

Copper is generally present in sediments at between one and two orders of magnitude over the ER-L, and slightly over the ER-M. Two sample locations (SED-03 and SED-05) exhibit anomalously high concentrations of copper. However, the detection frequency of copper concentrations above the soil criterion is low (3 percent), and copper is not detected above the criterion in on-site groundwater. Also, background sediments exhibit copper concentrations above the ER-L and ER-M.

Lead was detected at concentrations moderately above the ER-L in 34 of the 42 samples, and moderately above the ER-M in 12 of the 42 sediment samples. These concentrations are approximately one order of magnitude above the dissolved lead concentrations in the most

recent on-site groundwater data. However, lead appears to be contributed from background sources, due to the presence of elevated concentrations of lead in upstream samples.

Mercury was detected at concentrations moderately above the ER-L in 11 of the 46 samples, and moderately above the ER-M in 22 of the 46 sediment samples. The highest mercury concentration was detected in background sample SED-16-C (7 mg/kg). In addition, mercury was not detected in the most recent on-site groundwater data. Therefore, off-site sources of mercury are likely contributing to the elevated levels of mercury in the sediment.

Nickel was detected above the ER-L in 41 of 42 sediment samples, and over the ER-M in nearly 50 percent of the samples. However, nickel appears to be related to background conditions, since the highest concentrations of this metal are in upstream samples.

Zinc was detected at concentrations above the ER-L in 35 of the 42 samples, and moderately above the ER-M in 15 of the 42 sediment samples. In contrast, zinc was not identified in the groundwater above the criterion, and the detection frequency for zinc in soil above the criterion is very low. In addition, zinc is present at elevated concentrations in upstream sediment samples.

9.3.6.2 Surface Water

For the most part, COPECs in the sediment are not contributing to the elevated concentrations in the surface water. Based on a comparison of existing surface water data and the SWQC (Section 9.3), mercury, nickel and zinc are within one order of magnitude of the chronic SWQC.

Mercury was detected at a very low concentration (below the MDL) at slightly above the SWQC in only one of 17 samples, which was obtained from the Arthur Kill. Mercury was not detected in a duplicate sample collected at the same location. In addition, mercury was not detected in the most recent groundwater data, and has not been identified as a site-specific contaminant.

Nickel was detected in nine of the 17 surface water samples above the SWQC. The highest concentration of nickel detected in surface water was in background sample SW-10-C. Nickel was also detected at one order of magnitude lower than nickel concentrations in the most recent groundwater data.

Zinc was detected above the SWQC in only two of 17 surface water samples. In addition, zinc is not present above the criterion in on-site groundwater, and exhibits a very low detection frequency above the criterion in on-site soils.

9.4 Potential Migration Pathways

The BEE inspection described in Section 9.2 included a review of migration pathways to the on-site environmentally sensitive areas, including the Arthur Kill, Spa Spring Creek,

Woodbridge Creek and associated wetlands. Potential migration pathways generally include stormwater runoff from overland flow, discharge of shallow groundwater to surface water, and direct discharge of contaminants via spills or pipe outfalls.

9.4.1 Stormwater Pathways

Stormwater runoff from the Refinery is controlled by a network of catch basins and storm sewer piping, and generally flows into the OWSS. The OWSS connects to the ETP that discharges treated effluent to Woodbridge Creek. The discharge is regulated under an NJPDES-DSW permit. As a result, only very little incidental precipitation that falls along the banks of the adjacent water bodies and stream corridors actually reaches the surface water. The SWMUs and AOCs identified in Section 9.3.1 are adjacent to the surface water bodies to the north and east of the site. Based on the site inspection (Section 9.2), there are no significant stormwater discharge pathways from the on-site SWMUs and AOCs to the adjacent surface water bodies.

Groundwater Pathways

The migration of contaminants via groundwater was evaluated as a potential pathway for the migration of constituents detected in groundwater samples above the GWQS at the site. Although there were some hits of SVOCs and metals in the groundwater on-site, these constituents are generally immobile in groundwater. The groundwater did contain low to moderate concentrations of BTEX in a few places, but not close to the surface water bodies. Based on a review of the COPECs provided in Section 9.3 and the groundwater quality in the sentinel groundwater monitoring wells located along the creek banks, COPECs are not migrating to the creeks or to the Arthur Kill in groundwater.

9.4.2 Direct Discharge Pathway

Based on the BEE inspection, review of the file information and discussions with site personnel, there is one direct discharge to Woodbridge Creek from the ETP.

9.4.3 Potential Off-Site Sources

Both creeks are tidally influenced by the Arthur Kill, which has been impacted by numerous contaminant sources from surrounding industrial land use, roadway runoff and extensive, historical development (see Section 9.1.1). In addition, there is a significant potential for past and current atmospheric deposition of the contaminant found in the sediment and surface water related to the surrounding heavy industry and roadway traffic. These sources likely account for, or contribute to, the presence of elevated concentrations of chemical constituents detected in the creek sediments and surface water adjacent to the site.

9.5 BEE Summary Conclusions and Recommendations

9.5.1 Environmentally Sensitive Areas

As a result of the site inspection, and a review of the available wetlands maps and NJDEP's GIS data, the environmentally sensitive areas on or adjacent to the site include the Arthur Kill, Spa Spring Creek, Woodbridge Creek and associated wetlands areas located along the north, east and west site boundaries. There are no endangered/threatened species associated with the site and no observed impacts in the identified environmentally sensitive areas. Based on the BEE site inspection, the general conditions of the Kill, creeks and associated wetland areas appear to be similar to other estuarine surface water and wetland areas that are located in older, heavily industrial areas.

9.5.2 Contaminants of Potential Ecological Concern

Based on a review of the existing soil, groundwater, sediment and surface water analytical data, the COPECs at the Project site include benzene, xylenes, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, arsenic, lead and nickel in sediment, and nickel in surface water.

VOCs were detected in sediments at a relatively low detection frequency and at low concentrations that coincide with sediments exhibiting elevated SVOC concentrations. SVOCs were detected in most of the sediment samples, including background locations, at concentrations above the SSGs.

All of the metals identified as COPECs were detected above their respective SSGs in background samples collected from the Arthur Kill and Woodbridge Creek.

Based on the surface water analytical results, COPECs detected at elevated concentrations in the sediment samples generally do not appear to be partitioning to the water column.

9.5.3 Migration Pathways

Potential migration pathways were evaluated including the potential for stormwater discharges from overland flow, groundwater discharges to surface water, direct discharge of contaminants, and potential off-site sources. Based on this review, groundwater migration along the site perimeter and surface water runoff exhibit a low potential as migration pathways to the adjacent tidal creeks and wetland areas from Chevron. Also, groundwater migration and surface water runoff from off-site industrial properties and roadway runoff likely contribute contaminants to the adjacent tidal creeks and wetland areas.

9.5.4 Conclusions and Recommendations

Environmentally sensitive natural resources exist adjacent to the site, including Spa Spring Creek, Woodbridge Creek, Arthur Kill and associated wetlands and transition areas; however, environmentally sensitive areas are not present on site.

COPECs including VOCs, SVOCs and metals are present at the site in soil and groundwater at concentrations elevated above the RFI Delineation Criteria. Moderately high concentrations of SVOCs and metals were detected above SSGs in sediment samples collected from all three water bodies adjacent to the site. Nickel, mercury and zinc were detected above the SWQC in relatively few surface water sample locations at low concentrations.

Pathways for contaminant migration from SWMUs and AOCs to environmentally sensitive natural resources do not appear to be complete. All contaminated soil and groundwater areas adjacent to the property boundaries along Woodbridge Creek, Spa Spring Creek and the Arthur Kill have been delineated and do not extend to the environmentally sensitive areas.

There is no indication of ongoing discharges of hazardous substances from the site based on the soil and groundwater sample analysis, and LNAPL investigation.

Many area-wide, off-site, background sources are likely contributors to the presence of elevated concentrations of VOCs, SVOCs and metals in sediments, and to the slightly elevated metal concentrations in surface water. Staining and/or petroleum odors were also observed in several potential background locations in Woodbridge Creek sediment samples obtained from sampling transects SED-09 and SED-10 (see Vibracore Logs in Appendix D).

Based on the BEE, further evaluation of SVOCs and metal COPECs in the Woodbridge Creek sediments is recommended.

